

PAPERS ON PALEOPATHOLOGY

presented at the

Twelfth Annual Meeting



9 - 10 April 1985

Knoxville, Tennessee

SECTION 1: WORKSHOP/ROUND TABLES

Convener: Donald J. Ortner

IMAGING TECHNIQUES AND X-RAY FILM INTERPRETATION IN SKELETAL DISEASE

Donald J. Ortner, Smithsonian Institution, with A. Everette James, Theo Falke and E. Paul Nance Jr., Vanderbilt University

Drs. A. Everette James, E. Paul Nance Jr. and Theo Falke, Department of Radiology and Radiological Sciences at Vanderbilt University, provided a workshop on x-ray imaging and orthopaedic radiology for members of the Association. Dr. James, Chairman of the Department, discussed recent advances in imaging techniques, including xeroradiography, computed tomography, and nuclear magnetic resonance imaging. Recent developments in these radiological methods provide high resolution images of a variety of lesions of interest to the paleopathologist. Of considerable importance for mummy paleopathology is the fact that the methods are non-invasive and non-destructive. Dr. Theo Falke presented a report on the research that he has conducted on mummy specimens in the Netherlands.

Because the symposium for this year's meeting dealt with mycotic infection, Dr. Paul Nance reviewed the orthopaedic radiology of mycotic and other diseases that pose problems in differential diagnosis. Following that presentation, Nance and Ortner discussed three cases of possible mycotic infection from an archeological site in Alaska, which Ortner presented as part of the symposium the following day. The discussion highlighted the difficulty of differentiating between disease syndromes that have overlapping skeletal manifestations.

PATHOLOGY VERSUS PSEUDOPATHOLOGY IN SKELETAL SPECIMENS

Frank P. Saul, Medical College of Ohio, with Donald J. Ortner, Smithsonian Institution and Della Collins Cook, Indiana University

The session began with a brief review of what is meant by the term 'pseudopathology,' i.e. postmortem changes that mimic premortem pathology, but are due to cutting, breakage, soil chemistry, root action, and animal activity (including fungi, insects, rodents and so on). This category also includes the misinterpretation of essentially normal premortem, including growth,

changes and variation, i.e. vascular impressions and metaphyseal channels. Cook, Ortner and Saul presented a series of specimens and macroscopic and microscopic (SEM) techniques illustrating many of these changes, and some misinterpretations thereof. In addition, Cook presented a skull with an apparent trephination at Bregma that is probably due to congenital dysraphism, an old misdiagnosis that, although not strictly fitting the category of 'pseudopathology,' still reminds us of the need for distinguishing cultural from natural phenomena.

Although continuing to stress the need for avoiding over-diagnosis, Ortner and Saul presented specimens that indicated the possibility that true pathology might be overlooked when it mimics pseudopathology, e.g. probable mycotic infection in ancient Eskimo remains, and pathologic fractures due to metastatic cancer in a dissecting room specimen. This led to a stimulating discussion concerning the difficulties of distinguishing between perimortem and postmortem damage to bone, with valuable contributions by members of the 'audience.' It quickly became apparent that forensic and taphonomic research by ourselves and colleagues has much to offer along these lines.

Sheilagh Brooks (University of Nevada) provided an example that combined both fields, as she described a recent case in which several months of stream tumbling of a body over many miles produced a cranial defect that a local coroner ascribed to trephination.

J. Lawrence Angel (Smithsonian Institution), Marc Micozzi (National Cancer Institute), Michael R. Zimmerman (Jeanes Hospital), and others contributed information on subtle differences in cranial table fragmentation under varying circumstances. (NB: A later AAPA presentation by Russell, Shipman and Villa provided experimentally derived information on distinguishing among fresh and old cut marks on fresh and weathered bone as seen with the aid of scanning electron microscopy).

This session demonstrated that a surprisingly good interaction can be obtained in a less than ideal physical situation, if the subject matter is interesting, and the participants interested. (Ed. note: Remember Rutherford and the bicycle shed?)

DENTAL PALEOPATHOLOGY

Raymond L. Costa Jr., University of Illinois, with Ellis J. Neiburger, Waukegan, Ill., David Kingsnorth Patterson, Boston, Mass. and Jerome C. Rose, University of Arkansas

This discussion section was a great success, with twenty people attending, chiefly graduate students, dentists, and anthropologists. Jerome Rose brought several sets of 8 x 10 photographs of enamel defects, which were passed around and elicited much comment. Discussion centered on how different kinds of enamel defects (Wilson bands, hypoplasias, etc.) relate to each other, and how they can be diagnosed, with and without sectioning the teeth. David Patterson discussed his work concerning the relationship

of caries levels to diet and subsistence patterns in different groups of Canadian Iroquois Indians. This engendered a rich discussion from James E. Harris (Ann Arbor), Marc Kelley (University of Rhode Island), Robert Isler (Florida Atlantic University) and others, as they related the information presented to the archeological groups that they are studying. Ellis Neiburger (Waukegan, Ill.) talked briefly about dental wear and flat-plane occlusion, but before a good discussion could start, our limited time ran out. The general feeling was that we could easily have gone on all morning, and that next year we should aim for a formal symposium rather than a discussion section.

SECTION 2: CONTRIBUTED PAPERS

Moderator: John B. Gregg

THE MARY ROSE BURIALS: PATHOLOGY, WITH SPECIAL REFERENCE TO SOME LESIONS POSSIBLY RELATED TO OCCUPATIONAL ACTIVITY

Ann Stirland, Woodend, Nr. Towcester, England

A range of abnormalities is present in the burials from the Mary Rose, with the notable absence of some fractures. Dietary deficiencies appear to be quite widespread, with a high frequency of porotic hyperostosis, some cribra orbitalia, and enamel hypoplasia. There is a wide range of periosteal reaction of tibiae and fibulae, some quite severe. There are cases of osteochondritis dissecans, various forms of avulsion, and a considerable degree of spinal stress, all of which may be related to occupational activity. It is suggested that the high frequency of os acromiale already reported (Stirland 1984*), plus the degree of development of some fibrous insertions may also have occupational significance. (*Fifth European Members Meeting, p.14)

STUDY OF AN ANCIENT CADAVER EXCAVATED FROM MAWANGTUI TOMB NO. 1 IN HUNAN

Longxiang Peng, Hunan Medical College, China

Mawangtui Tomb No. 1 was excavated at the beginning of 1972. Over 1,500 valuable relics and the well-preserved body of an elderly female were unearthed from the tomb. As part of the archeological study of those relics, some were examined with radiocarbon, which showed that this tomb was buried about 2,100 years ago, i.e. in the early years of the Western Han Dynasty. Radiological and pathological examination, ultra-structural and parasitological study, chemical and instrumental analyses (such as neutron activation analysis and atomic absorption spectrometry) were performed on some organs and tissues.

The important findings were: general atherosclerosis; coronary artery atherosclerosis; multiple cholelithiasis; schistosomiasis japonica; chronic accumulation of lead and mercury; fracture of the distal end of the right ulna and radius with malunion; infections of enterobiasis and trichiuriasis, etc. In the esophagus, stomach, small and large intestines, one hundred and thirty eight and a half fresh muskmelon seeds were discovered, probably indicating that the woman died from an acute episode of cholelithiasis and a

heart attack shortly after eating the melon. In addition, the collagen fibers and cellular structures of some striated muscles and chondrocytes were surprisingly well preserved.

INTESTINAL PARASITES AND IRON DEFICIENCY ANEMIA IN THE PREHISTORIC SOUTHWEST

Carol Piacentini, University of Massachusetts

Iron deficiency anemia is well documented in prehistoric skeletal populations from the American southwest, and is commonly attributed to intensification of maize agriculture. This simple cause and effect relationship does not address the probable role of intestinal parasites, which were endemic in most early groups. Cultural changes, which accompanied increased maize production, provided a set of conditions conducive to continuous and widespread infection of these populations. Although maize dependence undoubtedly was a major contributing factor in the increase of iron deficiency through time, its etiology is more fully understood by assessing the synergetic effect of human parasitic infection. Attempts are currently being made to isolate parasite ova in soil samples recovered from southwest burials.

HUMAN PARASITE DIVERSITY IN THE PREHISTORIC SOUTHWEST

Karl J. Reinhard, Texas A & M University

Diversity and distribution of human helminth parasites in the prehistoric New World are poorly understood. The parasitological literature speculates that prehistoric human parasitism in the Americas was limited. Analysis of prehistoric feces in the southwestern United States reveals a surprising diversity of intestinal parasites. The genera identified include: Strongyloides(?), Ascaris, Hymenolepis, Trichostrongylus, Enterobius, Trichuris, and Moniliformes, as well as tapeworm genera in the family Taeniidae. This diversity of parasites in prehistoric fecal remains suggests that parasitism was a chronic problem faced by prehistoric Amerindians, and that many of the common human parasites of today parasitised prehistoric Indians.

TEMPORAL BONE PALEOPATHOLOGICAL STUDIES FROM TWO MEMBERS OF THE BARROW FROZEN FAMILY

Jaime T. Benitez, William Beaumont Hospital, Detroit

Ear pathology was investigated in two temporal bones from two individuals of the Barrow frozen family. X-ray polytomography revealed a rounded

soft tissue mass of about 4 mm in the epitympanum of the specimen from skeleton 3, suggesting cholesteotoma. The mastoid and the inner ear were normal in both specimens.

Zeiss operating microscope studies showed preservation of the lenticular process of the incus in both specimens. The oval windows and stapes bones showed no evidence of otosclerosis. Histology of the soft tissue mass showed epithelial tissue not consistent with cholesteotoma. Active osteoid seams were identified with undecalcified sections from both temporal bones.

USE OF WRITTEN DOCUMENTATION IN DIAGNOSES OF PRE-COLUMBIAN SYPHILIS

Brenda J. Baker, University of Massachusetts

The origin of syphilis has long been a point of controversy in paleopathology. In the absence of extensive skeletal evidence for syphilis, medical historians have turned to pre-Columbian written sources in an effort to document the existence or non-existence of syphilis in the Old World. Confusion between syphilis and leprosy in ancient literature has complicated the problem, as has the penchant of medical historians for citing the same source to support opposing theories. Historical references can be a useful and interesting supplement to evidence obtained from skeletal remains, but cannot offer substantive proof of the existence of particular diseases without such evidence.

AN ENDEMIC TREPONEMAL SYNDROME IN LATE PREHISTORIC ALABAMA INDIANS AT MOUNDVILLE

Mary Lucas Powell, Smithsonian Institution

Speculation concerning the presence of 'syphilis' among prehistoric Southeastern Moundbuilders has persisted for over a hundred years, though with reference to the venereal form. Recent reappraisals of the epidemiology of both venereal and non-venereal treponematosis indicate that non-urban, 'primitive' populations are more likely to harbor endemic non-venereal syndromes (yaws, treponarid and pinta) than the venereal form associated with urbanized populations. The observed demographic and anatomical distribution of skeletal lesions associated with treponematosis in a large sample (N=564) from Moundville matches more closely an endemic non-venereal model, suggestive of a syndrome that produced considerable morbidity in each generation but had little impact on mortality. The preponderance of well-healed non-destructive lesions indicates that the prehistoric syndrome was essentially self-limiting, as are the modern non-venereal syndromes. Old World populations in sub-tropical humid regions may display treponemal symptoms clinically intermediate

between yaws and treponarid, a pattern applicable to the Moundville series, which occupies a similar climatic locale.

DENTAL TREATMENT WITH A FLINT DRILL 5,000 YEARS AGO

Pia Bennike, University of Copenhagen, Denmark

Human remains of 53 individuals from a Neolithic passage grave were studied. There was evidence of dental treatment in the maxilla of an adult man. A circular hole, 4 mm in diameter, was seen in one molar, at the exposed part between the two facial roots of 7+. The hole did not affect the crown of the tooth. The depth of the conical hole was 6 mm.

Using a scanning electron microscope, small amounts of calculus were seen on the surface of the hole, indicating that it had been made in vivo. The tooth must have been treated intra vitam with a drill, probably because of pain due to pulpal involvement.

Experiments using flint drills and comparing the surfaces of holes made by a flint drill supported this theory.

This study was supported by the Danish Medical Research Council and the Danish Council of Humanities.

(Poster discussion)

TORSOMOLAR ANALYSIS: TRACING POPULATIONS THROUGH TIME

Ellis J. Neiburger, Waukegan, Illinois

There is a high genetic correlation between many population groups and tooth positions. In particular, the incidence of torsoversion (rotation) of mandibular third molars in select populations remains relatively constant over long periods of time. This comprises an easy to use genetic marker. Various prehistoric and modern groups are analyzed, and projections as to genetic relationships are made.

(Information regarding torsomolar analysis technique can be obtained from the author at 1000 North Avenue, Waukegan, IL 60085)

CHANGES IN THE INCIDENCE OF LINEAR ENAMEL HYPOPLASIA DURING 5000 YEARS OF SANTA BARBARA CHANNEL AREA PREHISTORY

Phillip L. Walker, University of California, Santa Barbara

The presence of linear enamel hypoplasia in prehistoric human skeletal remains from the Santa Barbara Channel area of southern California was assessed, using equations to estimate the duration of episodes of disrupted dental development. These data show that the incidence of hypoplasia increased markedly through time. There is also significant spatial variation in hypoplasia, with the late prehistoric period population of the Channel islands exhibiting less hypoplasia than their contemporaries in densely populated mainland coastal areas.

PRELIMINARY FINDINGS FROM THE TIA AND TIA BURIAL SITE, SAQQARA

Roxie Walker, Mill Valley, California

During January and February 1985, we excavated fifty-one complete and eighteen incomplete burials from an intrusive Late Period re-use of the New Kingdom tomb of the scribe Iurudef in the larger tomb enclosure of Princess Tia, sister of Ramses II, and her husband, also called Tia. We also recovered a substantial quantity of burned bones and water damaged disturbed burials dating from the original New Kingdom use of the tomb. All material has been removed from the tomb to the expedition magazine at Saqqara, where it has undergone preliminary conservation and recording. The incomplete burials, burned bones, and water damaged material require extensive conservation and sorting, which will be done next year. However, initial study of the complete Late Period burials has revealed several items of interest, including healed fractures, dental attrition and anomalies, possible spinal tuberculosis, invasive lesions of a sacrum and ischium, and unusual cranial development in several children, suggestive of hydrocephaly or abnormally soft or thin vault bones. Detailed studies of all material, including radiologic examination, will be done next winter. It should be interesting to compare the two populations we have here, as they vary in both socioeconomic class and time.

MAYA PALEOPATHOLOGY: 1985

Frank P. Saul and Julie M. Saul, Medical College of Ohio and A.J. Christoforidis, Ohio State University

The basic categories of trauma, treponematosi s, Paget's, scurvy, weanling disease, anemia, cultural influences, pseudopathology, dental disease and variations, and tuberculosis have been retained and expanded from the 1982 exhibit, and new sections added on congenital disorders and pathology of uncertain origin. Pre-Columbian examples of probable treponematosi s ('syphilis/yaws' now as early as 450 B.C.), tuberculosis, Paget's and other controversial diseases are now accompanied by examples of neurofibroma, spondylolysis, vascular impressions and root damage mimicking lesions, Klippel-Feil vertebrae, etc.

(Exhibit: work supported in part by National Science Foundation, National Geographic Society and National Institutes of Health)

SECTION 3: MYCOTIC INFECTIONS AND PROBLEMS OF DIFFERENTIAL DIAGNOSIS

Convener: Charles F. Merbs

INTRODUCTORY STATEMENT

Charles F. Merbs, Arizona State University

Although mycotic infections do not appear to have been major contributors to human misery and death in the past, they must be kept clearly in mind when diagnoses are being made. The mycoses most likely to include skeletal involvement are blastomycosis, coccidioidomycosis, the duboisii variety of histoplasmosis, paracoccidioidomycosis, and cryptococcosis. Several of the mycoses also affect non-human hosts such as other primates and dogs, providing evidence for these conditions in the absence of documented human cases. Mycoses are often great imitators of other diseases, and have thus been difficult to diagnose in ancient human remains. This symposium is unlikely to produce any major break-throughs in making such diagnoses any easier, but it will serve to make paleopathologists more aware of the problem and prompt them at least to consider the mycoses when making diagnoses.

POSSIBLE MYCOTIC INFECTION IN THREE ARCHEOLOGICAL CASES FROM ALASKA

Donald J. Ortner and James J. Krakker, Smithsonian Institution

Mycotic infection is uncommon among contemporary indigenous groups living in Alaska. In 1935 three possible paleopathological cases were excavated at Jones Point on Kodiak Island, Alaska by Aleš Hrdlička, and are part of the Smithsonian Institution's skeletal collection (catalog nos. 374750, 374754 and 374761). Unfortunately, the archeological dates cannot be established with precision, but the first two probably date to the period between 1000 and 1750 A.D., and the third to the historic period (post 1750).

All exhibit multiple lytic lesions indicative of a hematogenous dissemination of the disease. There is minimal reactive bone. The lesions appear to be infectious rather than neoplastic or reticuloendothelial in origin. The distribution and morphology of most lesions are compatible with a diagnosis of mycotic infection, although infectious conditions such as osteomyelitis

and tuberculosis should be considered. In specimen no. 374754, the fourth lumbar vertebral body is virtually destroyed, resulting in kyphosis. Destruction resulting in kyphosis is not common in mycotic spondylitis, and this raises the possibility of tuberculosis complicated by mycotic infection. Because mycotic infections are highly opportunistic, they might be expected to be a complicating factor associated with the debilitating effects of tuberculosis. The minimal evidence for mycotic infections in Alaska in modern times makes such a diagnosis in archeological material problematic. The distribution and morphology of the skeletal lesions, however, do not fit as well with other known skeletal disease syndromes.

POSSIBLE EVIDENCE FOR MYCOTIC DISEASE IN A LATE PREHISTORIC POPULATION FROM MIDDLE TENNESSEE

Leslie Eisenberg, New York University

A paleopathological analysis was made of the 888 individuals recently recovered from three cemeteries excavated at the Averbuch Site (40DV60) near Nashville, Tennessee. A number of burials exhibit severe lytic lesions, especially in the axial skeleton, which may represent evidence for mycotic disease in this Mississippian agricultural community dating from approximately 1275 to 1375 A.D.

A number of possible mycotic diseases affecting the population are discussed and a differential diagnosis offered, based on lesion description, distribution of the individual lesions, age and sex patterning throughout the population, and biocultural information derived from the archaeological excavation. It is suggested that some of the lesions may not represent a mycotic infection but may be due to tuberculosis, underscoring the difficulty involved in making an accurate differential diagnosis.

COCCIDIOIDOMYCOSIS INVOLVING THE CANINE SKELETON: A MODEL EXAMPLE OF LESION DEVELOPMENT FOR USE IN SOUTHWESTERN PALEOPATHOLOGY

T. Michael Fink, Arizona State University

Coccidioidomycosis is a fungal disease hyperendemic to the low deserts of southern Arizona. Although many aspects of the disease have been heavily researched, it is not known whether the causative agent, *Coccidioides immitis*, was present in antiquity. Research concerning the history of the disease has been hindered by the common practice of cremation in prehistory, and the destructive effects of desert soils on inhumations. However, the skeletal remains of the prehistoric Indian dog may serve as an alternative source for evidence concerning the antiquity of cocci, as canids are quite susceptible to infection and are more likely to develop skeletal lesions than humans. The skeleton of a recently deceased dog

illustrates the pattern and type of coccidioidal bone lesions that can develop in canids, i.e. productive lesions, bi-lateral involvement with asymmetrical lesion morphology, bony protuberance involvement, and a 'coral-like' proliferation of the pelvis. The animal may be used as a model for the type of skeletal pathology one would expect to see if cocci were present in antiquity.

MYCOTIC DISEASES IN SOUTH AMERICAN MUMMIES

Enrique Gerszten and Marvin J. Allison, Medical College of Virginia

In general, fungal diseases were rare in South America, many times an incidental finding at the time of autopsy. Today we have better techniques for making a diagnosis, and some modern treatments favor the development of opportunistic mycoses.

Some of the deep mycoses were first described in America: histoplasmosis in Panama, coccidioidomycosis in Argentina, and paracoccidioidomycosis in Brazil. With the exception of paracoccidioidomycosis in large areas of Brazil, Venezuela and Colombia, other mycoses are rare in South America.

In our large collection of mummies excavated from Peru and Chile, we were able to make a diagnosis of mycotic infections in only two cases. In one case, the lung on microscopic sections shows a yeast infection compatible with candidiasis. The second case was a mummy excavated from the north of Chile. The mummy was a middle aged woman who died around 290 A.D. with extensive cavitory disease of the right lung. On gross examination, this lesion was similar to either tuberculosis or a malignant primary tumor of the lung. Light and electron microscopic sections revealed an infection with a yeast form, which was compatible with paracoccidioidomycosis brasiliensis. Small miliary type lesions were seen in the kidney, and sections of the paratracheal lymph nodes showed yeast-like organisms. This case proves that South American blastomycosis or paracoccidioidomycosis was present in South America before European contact.

COCCIDIOIDOMYCOSIS IN THE PREHISTORIC SOUTHWEST: A PERSPECTIVE

Charles F. Merbs, Arizona State University

Coccidioidomycosis, better known as 'cocci' or 'valley fever,' is given credit for causing approximately 25 human deaths a year, just in Arizona. It also affects a wide variety of animals kept in the endemic area, including chimpanzees, gorillas, monkeys, dogs, and such exotic species as wallabies, binturongs, llamas, tapirs and sea lions. The chimpanzee and gorilla victims make excellent models for the skeletal involvement of the disease, particularly in the absence of documented skeletonized human cases. Cocci lesions in these two primate genera are primarily osteolytic in nature, closely resembling the lesions produced by tuberculosis. In one instance,

cocci appears to have been responsible for hypertrophic osteoarthropathy in a chimp, producing a symmetrical pattern of periosteal proliferative changes not usually associated with mycotic infection.

PANEL DISCUSSION

Panelists: Howard Duncan, Henry Ford Hospital (Detroit), Marc Kelly, University of Rhode Island and Marc Micozzi, National Cancer Institute

MK: Ortner's lesions are identical, or as close as one can get, to some of the lesions from the South Dakota Mowbridge site: I suspect that these are not tuberculosis as other people have concluded, because they do not fit the pattern at all. It is essential to use large samples in cases like this. If you have only one individual with lesions, it is hard to distinguish tuberculosis from blastomycosis, but when you have a couple of hundred individuals, with ten or twelve affected, there is little room for doubt that this is not tuberculosis. We should remember that the mycoses really are not that common, so we cannot get too generous every time we find a non-tuberculous skeletal lesion and diagnose it as mycotic. Regarding the case with rapid destruction of the vertebrae, I have seen the exact same pattern in a case where I do not think the changes were suggestive of tuberculosis. In Eisenberg's paper, there was a mixture of tuberculosis and 'something,' perhaps mycotic, plus some classic rib lesions of tuberculosis. That is not surprising, because you can have tuberculosis with superimposed mycotic infection. Gerszten's paper presented a very tight case for fungal infection. Fink and Merbs presented an intriguing difference in bone response in two different species. We might have assumed a similar pattern in humans and chimpanzees, although that is not necessarily so: this point needs further examination.

MM: Merbs and Fink have attempted to develop animal models to establish diagnostic criteria for these pathologic lesions. In studying tuberculosis, we have the advantage of going to skeletal collections, in which we have humans with known tuberculosis and thus can observe skeletal changes to establish diagnostic criteria. However, in coccidioidomycosis, animal models may be a more appropriate method to use.

CFM: One of the advantages of working with chimpanzees is that we were absolutely certain that it was not tuberculosis. Most of these animals came from a primate foundation, where they were constantly tested for tuberculosis. Most developed coccidioidomycosis at a specific time, when the foundation used the services of the National Guard to build a road at the foundation. Enormous amounts of dust got into the air, many of the animals came down with the disease, and some did not survive. This brings up the question: did prehistoric peoples in the southwest disturb the soil and make these spores airborne? For the Hohokam we have extensive building of canals, but hunter-gatherers may not have disturbed the layer in which the spores are found.

HD: In the northern part of North America, one does not see very much

of the mycoses except in the immuno-compromised human. It appears that the animals are not compromised in any way. In Ortner's human case, one wonders whether tuberculosis was a concomitant, or was there a hematologic abnormality such as myelomatosis? This also could contribute lytic lesions and predispose to the mycotic diseases.

EG: It is true that mycoses are rare diseases, but they always must be kept in mind. A few months ago, we had a patient in Richmond with respiratory failure. An x-ray showed multiple bilateral nodules in the lung, and the radiologist made a diagnosis of pulmonary carcinomatosis. At autopsy, the nodules were found to be blastomycosis. You must always think about diseases that can mimic carcinomatosis and vice versa.

CFM: In Arizona, people are concerned that 25 people a year die of coccidioidomycosis and many others are handicapped. The University of Arizona was sued by a black student from New Jersey for not telling him that blacks were at greater risk for coccidioidomycosis. Of course, the other problem is that some very valuable primates are lost to the disease. The time course is extremely variable, with the shortest time of onset being two months from the building of the road. The animal lost most of its motor ability within a period of about three weeks. Another animal died with extensive bone damage in the wrist, and that seemed to be all. Then there is everything in between. The condition is not necessarily disabling. I do not know why there is a higher incidence of infection in the primates than in the human population. I do not know whether any of the road workers were affected (but they were wearing masks). I was surprised at the low incidence among people in agriculture: I once saw a farmer plowing his field, in an airconditioned, completely enclosed tractor, but he was raising an enormous cloud of dust. We tried to do a test on our archaeologists, as the disease is an occupational hazard. During a field school in the spring, both the archaeologists and the physical anthropologists were absolutely wallowing in the dust of an excavation, but the only person to come down with cocci was a social anthropologist who came out to watch for one day.

LE: In archaeological populations, the context is very important, because mycoses are not transmitted from human to human or animal to human. Because infection comes from the soil, it is important to get as much archaeological information as possible on subsistence, type of settlement, density of settlement, etc. There does seem to be some kind of relationship between malnutrition and mycotic disease. In populations with high incidences of porotic hyperostosis, there is also a high incidence of periostitis.

CFM: We do not have any information on coccidioidomycosis in prehistoric Indians in the southwest, but the Pima Indians have a very high rate, much higher than Caucasians. Pimas also have the highest rate of diabetes in the world, so there might be some connection there. Logically, you would expect that people living in an endemic area would develop some degree of resistance to the disease, so it is surprising that the Pima appear to be so susceptible; on the other hand they are somewhat marginal in terms of subsistence and have this very high rate of diabetes.

DJO: If you look closely at most lytic processes, you will see slight

evidence of periosteal reaction. Whenever you see that, you can be very certain that you are talking about an antemortem process. In most cases of premortem lytic processes, there are very few things that will produce a sharply defined pattern after death. The best thing is to look for evidence of sclerosis, margination of the lesion, or evidence of remodelling in response to the lytic process or periosteal reaction adjacent to the lesion itself. (Audience comment that some lytic lesions are expansile).

TMF: We have been talking today about the diagnosis of coccidioidomycosis or the other mycoses based upon bone lesions, but it is important to remember that many of these diseases, cocci especially, are highly dependent on environmental prerequisites. It has only been about six thousand years since the fungus of coccidioidomycosis could have evolved in the southwest. Before that, the rainfall in Arizona was much greater and the vegetation much more savanna-like: cocci would not have been able to exist in such an environment. In discussing the Hohokam, we are assuming that the pathogen was there at that time and at the same stage as now. I have doubts about that. Cocci cannot survive with over three inches of rain, and has to have a certain pH level, very alkaline: this is an important point with respect to the presence of the disease and its antiquity in the southwestern United States.

MM: The mycotic diseases give us an opportunity to study diseases that are an expression of the interaction between host and environment. With the Pimas, and the high incidence of cocci, there have been extreme biological and cultural changes among the hosts, though environmental factors may have changed more gradually. From a paleoepidemiologic perspective, the diagnoses are population-based (i.e. the frequency of lesions in skeletal populations). From that we can work back to estimating rates of pulmonary infection in tuberculosis, for example, although the relative resistance of ancient populations may have been different from that seen in modern times. Many individuals come in contact with these organisms, and the question is why one individual develops the infection and another does not.

LE: The Averbuch site was not excavated in its entirety. We have a fairly reasonable sample of individuals under two and a half years, however. (Response to audience question).

MK: Tuberculosis seems to be more recognizable in adults, and therefore many people notice the lesions more easily and dwell on them more.

EG: These are all chronic diseases, lasting two to four years. The changes in the bone were surely accompanied by visceral changes, and these would have been the cause of death, not the bone lesions.

CFM: We were able to do necropsies on all the chimps and found that not only the lungs but most of the organs were affected. As far as cocci in general is concerned, the primary cause of death is meningitis.

DJO: Mycotic infections represent one of the really troublesome and greatly overlooked areas in paleopathology. We have some models on strategies that we might use, such as the work by Cook and Buikstra on the transition from hunters to agriculturists. We have to start looking

more carefully at geographic factors, where the epidemic areas are. We also have to look at historical factors, such as populations undergoing nutritional stress. Mycotic infections are opportunistic and occur when a person is in a weakened state, so if we can find situations with reasonable archaeological or other documentation that a population was under stress, we need to compare that with a similar population not under stress. These are paleo-epidemiologic strategies that do not depend on super careful diagnoses: it is a matter of looking at populations in different contexts, and we have natural laboratories in various fine collections. Everyone should realise that this represents an important diagnostic modality.

TMF: Are there any collections showing mycotic diseases? There is a very big difference between looking at dry bone and looking at radiographs. I am not aware of any good autopsy material showing mycotic lesions, or whether it might be possible to start a collection of suitable material.

MK: There is one documented case of blastomycosis in the Terry collection. You need documented cases to get a firm ground for diagnosis, because each bone disease is surprisingly distinct, considering that the bone can respond in so few ways.

TMF: In dogs you have proliferative lesions, in humans lytic lesions, and in chimps you get both, which is a problem when trying to use the chimp model.

MM: There is no reason to believe that various medical systems were not efficacious in dealing with endemic diseases, and some of these interventions may have been lost with contact. The fact that individuals survived long enough to develop skeletal lesions may indicate not only resistance, but also the presence of a certain level of care, or the effectiveness of an intervention. This should be looked into, particularly with post-contact changes in disease patterns.

CFM: Cocci falls into the category of what the Pima would call a 'stain disease,' that is, an endemic disease. Looking at the symptomatology of 'stain diseases' to see if any match that of cocci might tell us something about the history of the disease in that area and how it may have been dealt with culturally.

And now, to close this discussion, I offer these words of wisdom: Proceed, but proceed with caution, and keep mycoses in the forefront of your thoughts.

(Discussion transcribed by Michael R. Zimmerman, summarized by T.A. Reyman and Eve Cockburn)

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